times, and the slow but mighty influences of denudation and deposition are forever at work. And so, perchance, in some remote age the vanished Gondwána Land, the lost Atlantis, may once again arise, the seeds of resurrection even now being sown upon their graves from the endless harvests of pelagic life.

JOHN JOLY

## *REPORT OF THE INTERNATIONAL CONFERENCE ON ELECTRICAL UNITS AND STANDARDS, 1908*

THE report shows that delegates were present from 21 countries, and also from the following British dependencies, namely, Australia, Canada, India and the Crown Colonies.

The total number of delegates to the conference was 43, and their names are set out in schedule A. The conference and its technical committee each held five sittings. As a result of its deliberations, the conference adopted the resolutions and specifications set out in schedule B, and requested the delegates to lay them before their respective governments with a view to obtaining uniformity in the legislation with regard to electrical units and standards.

The conference recommends the use of the Weston normal cell as a convenient method of measuring both electromotive force and current when set up under the conditions specified in schedule C.

In cases in which it is not desired to set up the standards provided in the resolutions of schedule B, the conference recommends the following as working methods for the realization of the international ohm, the ampere and the volt:

1. *For the International Ohm.*—The use of copies, constructed of suitable material and of suitable form and verified from time to time, of the international ohm, its multiples and sub-multiples.

2. *For the International Ampere.*—(*a*) The measurement of current by the aid of a current balance standardized by comparison with a silver voltameter; or

(*b*) The use of a Weston normal cell whose electromotive force has been determined in terms of the international ohm and international ampere, and of a resistance of known value in international ohms.

3. *For the International Volt.*—(*a*) A comparison with the difference of electrical potential between the ends of a coil of resistance of known value in international ohms, when carrying a current of known value in international amperes; or

(*b*) The use of a Weston normal cell whose electromotive force has been determined in terms of the international ohm and the international ampere.

The duty of specifying more particularly the conditions under which these methods are to be applied has been assigned to the permanent commission, and, pending its appointment, to the scientific committee, to be nominated by the president (see schedule D), who will issue a series of notes as appendix to this report.

The conference has considered the methods that should be recommended to the governments for securing uniform administration in relation to electrical units and standards, and expresses the opinion that the best method of securing uniformity for the future would be by the establishment of an international electrical laboratory with the duties of keeping and maintaining international electrical standards. This laboratory to be equipped entirely independently of any national laboratory.

The conference further recommends that action be taken in accordance with the scheme set out in schedule D.

SCHEDULE A.—LIST OF COUNTRIES AND DELEGATES

America (United States).—Dr. S. W. Stratton; Dr. Henry S. Carhart; Dr. E. B. Rosa.

Austria.—Dr. Viktor Edler von Lang; Dr. Ludwig Kusminsky.

Belgium.—Professor Eric Gérard; M. Clement.

Brazil.—Mr. L. Weiss.

Chile.—Don Victor Eastman.

Colombia.—Don Jorge Roa.

Denmark and Sweden.—Professor S. A. Arrhenius.

Ecuador.—Sr. Don Celso Nevares.

France.—Professor Lippmann; M. R. Benoît; M. de Nerville.

Germany.—Professor Warburg; Professor Jaeger; Professor Lindeck.

Great Britain.—The Right Hon. Lord Rayleigh (President); Professor J. J. Thomson; Sir John Gavey; Dr. R. T. Glazebrook; Major W. A. J. O'Meara; Mr. A. P. Trotter.

Guatemala.—Dr. Francisco de Arce.

Hungary.—Joseph Váter; Dr. Desiré Harsanyi.

Italy.—Professor Antonio Ròiti.

Japan.—Dr. Osuke Asano; Mr. Shigeru Kondo.

Mexico.—Don Alfonso Castelló; Don José Maria Perez.

Netherlands.—Dr. H. Haga.

Paraguay.—M. Maximo Croskey.

Russia.—Dr. N. Engoroff, Col. L. Swentorzetzky.

Spain.—Don José Maria Madariaga; Don A. Montenegro.

Switzerland.—Dr. Fr. Weber; Dr. Pierre Chappuis; Dr. J. Landry.

BRITISH COLONIES

Australia.—Mr. Cecil W. Darley; Professor Threlfall.

Canada.—Mr. Ormond Higman.

Crown Colonies.—Major P. Cardew.

India.—Mr. M. G. Simpson.

Secretaries.—Mr. M. J. Collins; Mr. W. Duddell; Mr. C. W. S. Crawley; Mr. F. E. Smith.

SCHEDULE B.—RESOLUTIONS

I. The conference agrees that as heretofore the magnitudes of the fundamental electric units shall be determined on the electromagnetic system of measurement with reference to the centimeter as the unit of length, the gram as the unit of mass and the second as the unit of time.

These fundamental units are (1) the ohm, the unit of electric resistance which has the value of 1,000,000,000 in terms of the centimeter and second; (2) the ampere, the unit of electric current which has the value of one tenth (0.1) in terms of the centimeter, gram and second; (3) the volt, the unit of electromotive force which has the value 100,000,000 in terms of the centimeter, the gram and the second; (4) the watt, the unit of power which has the value of 10,000,000 in terms of the centimeter, the gram and the second.

II. As a system of units representing the above and sufficiently near to them to be adopted for the purpose of electrical measurements and as a basis for legislation, the conference recommends the adoption of the international ohm, the international ampere and the international volt defined according to the following definitions.

III. The ohm is the first primary unit.

IV. The international ohm is defined as the resistance of a specified column of mercury.

V. The international ohm is the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grams in mass, of a constant cross-sectional area and of a length of 106.300 centimeters.

To determine the resistance of a column of mercury in terms of the international ohm, the procedure to be followed shall be that set out in specification I. attached to these resolutions.

VI. The ampere is the second primary unit.

VII. The international ampere is the unvarying electric current which, when passed through a solution of nitrate of silver in water, in accordance with the specification II. attached to these resolutions, deposits silver at the rate of 0.00111800 of a gram per second.

VIII. The international volt is the electrical pressure which, when steadily applied to a conductor whose resistance is one international ohm, will produce a current of one international ampere.

IX. The international watt is the energy expended per second by an unvarying electric current of one international ampere under an electric pressure of one international volt.

SPECIFICATION I.—SPECIFICATION RELATING TO MERCURY STANDARDS OF RESISTANCE

The glass tubes used for mercury standards of resistance must be made of a glass such that the dimensions may remain as constant as possible. The tubes must be well annealed and straight. The bore must be as nearly as possible uniform and circular, and the area of cross-section of the bore must be approximately one square millimeter. The mercury must have a resistance of approximately one ohm.

Each of the tubes must be accurately calibrated. The correction to be applied to allow for the area of the cross-section of the bore, not being exactly the same at all parts of the tube, must not exceed 5 parts in 10,000.

The mercury filling the tube must be considered as bounded by plane surfaces placed in contact with the ends of the tube.

The length of the axis of the tube, the mass of mercury the tube contains, and the electrical resistance of the mercury are to be determined at a temperature as near to 0° C. as possible. The measurements are to be corrected to 0° C.

For the purpose of the electrical measurements, end vessels carrying connections for the current and potential terminals are to be fitted on to the tube. These end vessels are to be spherical in shape (of a diameter of approximately 4 centimeters), and should have cylindrical pieces attached to make connections with the tubes. The outside edge of each end of the tube is to be coincident with the inner surface of the corresponding spherical end vessel. The leads which make contact with the mercury are to be of thin platinum wire fused into glass. The point of entry of the current lead and the end of the tube are to be at opposite ends of a diameter of the bulb; the potential lead is to be midway between these two points. All the leads must be so thin that no error in the resistance is introduced through conduction of heat to the mercury. The filling of the tube with mercury for the purpose of the resistance measurements must be carried out under the same conditions as the filling for the determination of the mass.

The resistance which has to be added to the resistance of the tube to allow for the effect of the end vessels is to be calculated by the formula:

$$A = \frac{0.80}{1{,}063\pi}\left(\frac{1}{r_1}+\frac{1}{r_2}\right) \text{ ohm},$$

where $r_1$ and $r_2$ are the radii in millimeters of the end sections of the bore of the tube.

The mean of the calculated resistances of at least five tubes shall be taken to determine the value of the unit of resistance.

For the purpose of the comparison of resistances with a mercury tube the measurements shall be made with at least three separate fillings of the tube.

SPECIFICATION II.—SPECIFICATION RELATING TO THE DEPOSITION OF SILVER

The electrolyte shall consist of a solution of from 15 to 20 parts by weight of silver nitrate in 100 parts of distilled water. The solution must only be used once, and only for so long that not more than 30 per cent. of the silver in the solution is deposited.

The anode shall be of silver, and the cathode of platinum. The current density at the anode shall not exceed 1/5 ampere per square centimeter and at the cathode 1/50 ampere per square centimeter.

Not less than 100 cubic centimeters of electrolyte shall be used in a voltameter.

Care must be taken that no particles which may become mechanically detached from the anode shall reach the cathode.

Before weighing, any traces of solution adhering to the cathode must be removed, and the cathode dried.

SCHEDULE C.—WESTON NORMAL CELL

The Weston normal cell may be conveniently employed as a standard of electric pressure for the measurement both of e.m.f. and of current, and when set up in accordance with the following specification, may be taken, provisionally,[1] as having, at a temperature of 20° C., an e.m.f. of 1.0184 volts.

SPECIFICATION RELATING TO THE WESTON NORMAL CELL

The Weston normal cell is a voltaic cell which has a saturated aqueous solution of cadmium sulphate ($CdSO_4$ 8/3 $H_2O$) as its electrolyte.

The electrolyte must be neutral to Congo red.

The positive electrode is mercury.

The negative electrode of the cell is cadmium amalgam consisting of 12.5 parts by

[1] See duties of the scientific committee, schedule D.

weight of cadmium in 100 parts of amalgam.

The depolarizer, which is placed in contact with the positive electrode, is a paste made by mixing mercurous sulphate with powdered crystals of cadmium sulphate and a saturated aqueous solution of cadmium sulphate.

The different methods of preparing the mercurous sulphate paste are described in the notes.[2] One of the methods there specified must be carried out.

For setting up the cell, the H form is the most suitable. The leads passing through the glass to the electrodes must be of platinum wire, which must not be allowed to come into contact with the electrolyte. The amalgam is placed in one limb, the mercury in the other.

The depolarizer is placed above the mercury and a layer of cadmium sulphate crystals is introduced into each limb. The entire cell is filled with a saturated solution of cadmium sulphate and then hermetically sealed.

The following formula is recommended for the e.m.f. of the cell in terms of the temperature between the limits 0° C. and 40° C.

$$E_t = E_{20} - 0.0000406\ (t - 20°) - 0.00000095\ (t - 20°)^2 + 0.00000001\ (t - 20)^3.$$

SCHEDULE D

1. The conference recommends that the various governments interested establish a permanent international commission for electrical standards.

2. Pending the appointment of the permanent international commission, the conference recommends[3] that the president, Lord Rayleigh, nominate for appointment by the conference a scientific committee of 15 to advise as to the organization of the permanent commission, to formulate a plan for and to direct such work as may be necessary in connection with the maintenance of standards, fixing of values,[4] intercomparison of standards and to complete the work of the conference.[5] Vacancies on the committee to be filled by cooptation.

3. That laboratories equipped with facilities for precise electrical measurements and investigations should be asked to cooperate with this committee and to carry out, if possible, such work as it may desire.

4. The committee should take the proper steps forthwith for establishing the permanent commission, and are empowered to arrange for the meeting of the next conference on electrical units and standards, and the time and place of such meeting should this action appear to them to be desirable.

5. The committee or the permanent international commission shall consider the question of enlarging the functions of the international conference on weights and measures, with a view to determining if it is possible or desirable to combine future conferences on electrical units and standards with the international conference on weights and measures, in place of holding in the future conferences on electrical units and standards. At the same time it is the opinion of the conference that the permanent commission should be retained as a distinct body, which should meet at different places in succession.

[2] Notes on methods pursued at various standardizing laboratories will be issued by the scientific committee or the permanent commission, as an appendix to this report.

[3] In accordance with the above, Lord Rayleigh has nominated the following committee, which has been approved by the conference, viz: Dr. Osuke Asano, M. R. Benoît, Dr. M. N. Egoroff, Professor Eric Gérard, Dr. R. T. Glazebrook, Dr. H. Haga, Dr. L. Kusminsky, Professor G. Lippmann, Professor A. Rôiti, Dr. E. B. Rosa, Dr. S. W. Stratton, Mr. A. P. Trotter, Professor E. Warburg, Professor Fr. Weber.

[4] This will include the reconsideration, from time to time, of the E.M.F. of the Weston normal cell.

[5] With this object the committee are authorized to issue as an appendix to the report of the conference notes detailing the methods which have been adopted in the standardizing laboratories of the various countries to realize the international ohm and the international ampere, and to set up the Weston normal cell.

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*OTIS TUFTON MASON*

On November 5, 1908, death claimed Professor Otis T. Mason, for the past six years head curator of the Department of Anthro-